Effect of Sodium Chloride on Silica Fume Based M$_{30}$ Grade Concrete

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Abstract-- This paper presents the effect of Sodium Chloride (NaCl) on Conventional Concrete (Silica Fume Based M30 Grade Concrete). The Silica Fume Based M30 Grade Concrete was prepared by adding NaCl concentrations of 0.5, 2, 4, 6, 8, 10 and 12 g/l in deionised water. In addition to this, control specimen was prepared with deionised water (without NaCl) for the purpose of comparison. The tensile strength and compressive strength were evaluated for 28 and 90 days. The results show that as NaCl concentration increases compressive strength of silica fume based M30 grade concrete increases as the concentration of NaCl goes up at both 28 and 90 days only up to some extent. But the increase in the concentrations of NaCl has detrimental effect on the setting time of concrete after certain increase in the NaCl concentrations. Compressive strengths and Split tensile strength of Conventional Concrete show increases when compared with controlled specimen.

Keywords-- Silica fume, NaCl, Initial and final setting time, Compressive strength, Split tensile Strength.

I. INTRODUCTION

Water is considered to be an important ingredient in the both fresh and hardened state of Concrete. Cement is a mixture of several complex compounds, the cement reacts with water and forms paste which leads to setting and hardening by hydration process. All the compounds present in the cement are anhydrous, but when brought in contact with water, they get hydrolyzed, forming hydrated compounds. The quality of water is to be maintained strictly during the process of concrete making. As the water helps to form the vital strength giving cement gel. Natural water is available abundantly, as a good solvent. But there are more chances of containing large number of impurities ranging from less to very high concentration. Many studies show more importance on properties of cement and aggregate, but the quality of water is often neglected.

In general scenario water used for concrete mixing is considered to be suitable if the water is portable i.e., if it is fit for drinking, it is fit for making concrete. This isn’t true for all conditions.

Sometimes, water containing a small amount of sugar would be suitable for drinking, but not for making concrete and conversely water suitable for making concrete may not be necessarily be suitable for drinking, especially if the water contains pathogenic microbiological contaminants. The adverse impact of various deicing chemicals and exposure conditions on concrete materials were studied by Kejin et al., and results indicated that the various deicing chemicals penetrated at different rates into a given paste and concrete resulting in different degree of damages [1]. Gorininiski et al., presented an assessment of the chemical resistance of eight different compositions of polymeric mortars [2]. Adnan et al., reported the effects of environmental factors on the addition and durability characters of epoxy bonded concrete prisms [3]. Fikret et al., investigated the resistance of mortars to magnesium sulphate attack and results reported that there is a significant change in compressive strength properties [4]. Venkateswara Reddy et al., studied the influence of strong alkaline substances (Na$_2$CO$_3$ and NaHCO$_3$) in mixing water on strength and setting properties of concrete [5]. In many places ground water and surface water contains the impurities, more than that of limits specified by the IS 456:2000 [6]. Ali Reza Bagheri et al., in their study on the effect of incorporation of silica fume in enhancing strength development rate and durability characteristics of binary concretes [7]. Erhan Guneyisi et al., investigated the effectiveness of metakaolin (MK) and silica fume (SF) on the mechanical properties, shrinkage, and permeability related to durability of high performance concretes [8].

II. MATERIAL USED AND THEIR PROPERTIES

A. Cement

The ultra tech 53 grade ordinary Portland cement which conforms to IS 12269-1987, is used in the present study. The specific gravity is 3.14: initial and final setting times are 133 min and 365 min.
B. Silica fume

The Silica - Astra chemicals Ltd-Chennai which conform to ASTM C 1240 and IS 15388:2003. It is in white powder form premium micro silica which contains latently reactive silicon dioxide and no chloride or other potentially corrosive substances. The physical and chemical properties are mentioned in Table 1.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Properties</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Form</td>
<td>Ultra fine amorphous powder</td>
</tr>
<tr>
<td>2</td>
<td>Colour</td>
<td>White</td>
</tr>
<tr>
<td>3</td>
<td>Specific gravity</td>
<td>2.63</td>
</tr>
<tr>
<td>4</td>
<td>Pack Density</td>
<td>0.76 gm/cc</td>
</tr>
<tr>
<td>5</td>
<td>Specific surface</td>
<td>20 m²/g</td>
</tr>
<tr>
<td>6</td>
<td>Particle size</td>
<td>15µm</td>
</tr>
<tr>
<td>7</td>
<td>Sio₂</td>
<td>99.89%</td>
</tr>
</tbody>
</table>

C. Aggregates

The fine and coarse aggregates occupy about 60–75 per cent of the concrete volume (70–85% by mass) and hence strongly influence the properties of fresh as well as hardened concrete, its mixture proportions, and the economy. Aggregates used in concrete should comply with the requirement. Aggregates are commonly classified into fine and coarse aggregates.

Fine Aggregates: It is generally consisting of natural sand or crushed stone with particle size smaller than about 5 mm (materials passing through 4.75 mm IS sieve). The physical properties like specific gravity, bulk density are tested procured from local market at Kurnool.

Coarse Aggregates: It consists of one or a combination of gravels or crushed stone with particle size larger than 5 mm (usually between 10 mm and 40 mm). The crushed coarse aggregate of 20mm maximum size as well as 12mm size are obtained from the local crushing plant at confirming to Zone II, is used in the present study, the physical properties of the coarse aggregate like specific gravity tested.

D. Water

Deionised water has been used for mixing as well as curing of concrete for control specimens in the present investigation. The characteristics of deionised water, to which various chemical substances were spiked to obtain neutral salt, strong alkaline, slightly acidic and acidic water, are presented in the Table 2.

The control sample which is prepared with deionised water as mixing water and did not contain any chemical additives was used as the basis of comparison for examining the effects of the chemicals on the properties of concretes.

Chemical Substances: Water samples from different water bodies and also from various industrial chemical effluents were collected and analyzed for chemical and biological components. Among these components, the most commonly found components were identified along with their concentrations in treated effluents. Based on this information, NaCl chemical component with various concentrations were selected for the experimental work. Table 3 gives the range of NaCl concentrations and pH values.

III. EXPERIMENTAL PROGRAM

In this experimental work, specimens were cast using M30 grade mix design and for replacement of cement as silica fume used. The influence of NaCl at different concentrations was studied when the NaCl is spiked with deionised water. Test samples were compared with the control samples. This comparison may not be possible in case of control samples made with locally available portable water since it varies in chemical composition from place to place. With the above reason, NaCl was mixed with deionised water as per the dosage mentioned above. This water was used for preparation of test samples for determining the Compressive strength & Split Tensile Strength of Conventional Concrete, also used for curing samples.
A. Sample preparation and Curing

For each batch of concrete mix, 3 cubes (150mm x 150mm x 150mm), 3 cylinders (150mm x 300 mm) were cast to compute compressive strength and split tensile strength respectively. Specimens were demoulded after 24 hours then they allowed for chemical curing. The curing ponds consists the same concentration of chemical substance in water, which was used for mixing the concrete. The specimens were cured for 28 days and 90 days strength. The specimen were removed from the caring ponds after the required period and allowed to dry under shade.

B. Testing

Both cubes specimens and cylinders were tested using compressive testing machine of capacity of 2000KN. average of 3 cube compressive strength and 3 cylinder split tensile strength were recorded at 28 days and 90 days respectively.

IV. RESULTS AND DISCUSSION

A. Effect of NaCl on Setting time of Cement

The effect of NaCl on initial and final setting times is show in Fig 1, from which it is Concentration in deionised water .IS 456:20009 (Clause 5.4.1.3)[6] Stipulates that When the difference in setting time(S) is less than 30 minutes, the change is considered to be significant Form the experimentation work it is observed that, when the NaCl concentration exceeded 12 g/l, the acceleration of initial and final setting time of cement .When NaCl content is 20 g/l (maximum), initial setting time was 95 minutes which is 38 minutes less than of control mix. Similarly, a significant difference of 39 minutes was observed in the case of final setting time.

<table>
<thead>
<tr>
<th>S.NO</th>
<th>Water sample</th>
<th>Setting time in minutes</th>
<th>Initial</th>
<th>Final</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Deionised water</td>
<td>133</td>
<td>361</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.5</td>
<td>126</td>
<td>354</td>
<td></td>
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<tr>
<td>3</td>
<td>2</td>
<td>116</td>
<td>347</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>112</td>
<td>340</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>109</td>
<td>336</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>8</td>
<td>107</td>
<td>333</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>10</td>
<td>106</td>
<td>332</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>12</td>
<td>103</td>
<td>330</td>
<td></td>
</tr>
</tbody>
</table>

B. NaCl effect on compressive strength of Silica Fume based M30 Grade Concrete

The effect of NaCl concentration on the compressive strength of silica fume based M30 grade concrete is presented in Table 2 and Fig. 1. The degree of variation in compressive strength is also presented in Fig. 1. The results indicated that there is a gain in compressive strength of the silica fume based M30 grade concrete irrespective of NaCl concentration. In case of silica fume based m30 grade concrete, marked increase in 28 days and 90 days compressive strength is observed with increase in concentration of NaCl but there is no significant change at any concentrations. Compressive strength for silica fume based M30 grade concrete, with NaCl concentration from 0.5 to 12 g/l, has increased from 33.02 to 36.2 and 33.18 to 36.36 for 28 and 90 days aged specimen of 5% Silica fume replacement and increased from 33.89 to 38.33 and 34.13 to 38.4 for 28 and 90 days aged specimen of 10% Silica fume replacement respectively.
C. NaCl effect on Split Tensile strength of Silica Fume based M30 Grade Concrete

The effect of NaCl concentration on the Split Tensile strength of silica fume based M30 grade concrete is presented in Table 3 and Fig. 2. The degree of variation in Split Tensile strength is also presented in Fig. 2. The results indicated that there is a gain in Split Tensile strength of the silica fume based M30 grade concrete irrespective of NaCl concentration. In case of silica fume based M30 grade concrete, marked increase in 28 days and 90 days Split Tensile strength is observed with increase in concentration of NaCl but there is no significant change at any concentrations.

Split Tensile strength for silica fume based M30 grade concrete, with NaCl concentration from 0.5 to 12 g/l, has increased from 2.89 and 3.48 to 3.72 for 28 and 90 days aged specimen of 5% Silica fume replacement and increased from 3.84 and 4.46 to 4.64 for 28 and 90 days aged specimen of 10% Silica fume replacement respectively.
V. CONCLUSION

Based on the results obtained in the present investigation the following conclusions can be drawn:

- It is observed that as NaCl concentration increases, there is a retarder in initial and final setting of OPC 53 grade cement.
- The compressive strength of concrete is found to increase from 33.27 to 38.40 MPa as the silica fume content increases from 5 to 10% after 28 days and 90 days curing respectively.
- The split tensile strength of concrete is found to vary from 2.89 to 4.94 MPa with the 5 to 10 percent replacement of cement by silica fume from. However split tensile strength of concrete is increased with increasing silica fume content.
- The result showed that the substitution of 10% of the cement content by silica fume powder induced higher compressive strength and splitting tensile strength, and improvement of properties related to durability.
- Based on this limited investigation, silica fume content can be used as partial replacement of cement up to some extent.

REFERENCES


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**BIOGRAPHIES**


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